Insights into explosive mechanisms controlling lava fountains from remote sensing gas measurements

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The southeast crater (SEC) of Etna produced fifteen lava fountains in the period June-July 2001, immediately before the 2001 flank eruption. Here we present results from remote sensing measurements of the gas phase powering nine of these events, measured using FTIR (Fourier transform infrared) spectrometry. The spectrometer (Bruker OPAG-22) was located approximately 1 km distance from SEC, and spectra were collected every ~6 s using lava jets as the source of radiation. Spectra were analysed using a non-linear least squares fitting procedure and a forward model with spectral information from the HITRAN database. One challenge posed by measuring a lava fountain is the rapidly changing temperature of the absorbing gases. This was addressed by fitting the volcanic gas temperature together with gas amount during analysis of a SO2 absorption band at 2500 cm-1. With this approach we were able to robustly measure SO2, HCl and HF and, with greater difficulty due to atmospheric interference, CO2 and H2O. Previous work (Allard et al., Nature, 2005) on one similar lava fountain at SEC in June 2000 has shown that the probable mechanism driving the activity is accumulation of a bubble foam layer ~2 km beneath SEC. Here we analyse and interpret the temporal variations of SO2/HCl ratio during each event, and compare with contemporaneous measurements of the volcanic tremor and video recordings of the activity. We find that the measured gas composition displays a close relationship with the evolution of eruptive activity in three successive phases: i) lava effusion and steadily increasing Strombolian activity, ii) eruption paroxysm culminating in the lava fountain itself, and iii) post-paroxysmal phase with weakening Strombolian activity. Distinct gas compositions can be attributed to each phase of this sequence, constraining the physical mechanism at the origin of the fountaining event.